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***Abstract*-RFID tag antenna which could be mountable on metallic plate is designed and measured for 900MHz band. The proposed antenna consists of ground plane, substrate (ε_r = 4.7), feed line with shorted circuit and radiating patch with L-shaped slit. The feed line with shorted circuit is designed for the direct impedance matching between the antenna and the RFID microchip. Especially, it is possible to obtain considerably the easy impedance match with the proposed design. Overall dimension of the proposed antenna is 90×54×5mm^3. When the antenna is placed in free space and mounted on 125×150mm^2, 250×300mm^2 metallic plates, the maximum reading distance is 6m, 4.8m and 5.2m, respectively.**

I. Introduction

In recent years radio frequency Identification (RFID) of objects has become very popular in many service industries, distribution logistics, and manufacturing companies [1]. RFID technology is an automatic way for data transaction in object identification without human intervention or error. RFID system consists of a reader that uses an antenna to transmit radio energy to interrogate a transponder or tag that is attached to the item to be identified. Inductively coupled short-range RFID is already widely used, but demand is growing in the field of long-range identification, where electromagnetic waves and an antenna are used for coupling. Passive RFID tags harvest all of their operating power from the reader's communication signal, and it consists of a microchip and an antenna. Antenna impedance varies with objects which tag antenna is mounted on. Therefore, a tag antenna has to be designed and optimized for a particular object and location on that object [2]. Especially, metallic object strongly affects on the performance of a particular antenna often by degrading the tag's radiation efficiency. However, various metallic objects are common in most applications that utilize passive RFID system. Therefore, tag antennas have to be designed to enable passive tags to be read near and on metallic objects without performance degradation. To overcome this, studies on planar inverted-F antennas (PIFAs) have been presented and discussed [3]-[4]. The most important factor for antenna design of RFID tag is the effective impedance matching between the antenna and the microchip. The impedance of the conventional tag antenna with the direct feeding technique is matched by optimizing radiating element in order to cancel the large imaginary part of impedance of RFID microchip. However, the impedance levels of the microchips from each company are different from the common 50 Ω case, and their own values are also different each other. Thus, radiating element of RFID antenna has to be modified to directly match the impedance for each different microchip. This is extremely difficult and may result in the lower radiation efficiency. In this paper the effective impedance matching method in conjunction with the proximity coupled the feed line with shorted circuit is proposed. This method does not require the major modification of the radiating element to match the impedance between the antenna and microchip.

II. STRUCTURE AND DESIGN

Fig. 1 shows the structure of the proposed antenna. The antenna includes the ground (90×54mm^2), air layer (thickness: 4.4mm) and FR4 layer (ε_r=4.7, thickness: 0.6mm). Total height of the antenna is 5mm. Size of the radiator is 82×46mm^2 and it has L shape slits to increase the electrical length. The impedance of the microchip is (6.7-j197.4) Ω at 915MHz. To transmit the maximum power between the antenna and the microchip, it has to be conjugate matching. Real and imaginary parts of the impedance of the microchip are considered to match. First, the real part of the impedance depends on the gap between the feed line and the radiator and the location of the microchip on the feed line. As the gap becomes narrower the magnetic field density is increased so that the real part of the impedance becomes larger. The microchip is placed at vicinity of 1/4 wavelength from the open point. As it moves toward the open point the real part of the impedance is increased. The imaginary part of the impedance is controlled by the total length of the feed line with the shorted plate. Especially, inserting the shorted plate on feed line reduces the length of feed line by half, and it has effects on both the prevention of spurious radiation from the feed line and reduction of the ohmic loss on the feed line. The total length of the feed line is about 0.4λ and it is proper for

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conjugate matching with the microchip. As shown in Fig. 2, the maximum magnetic field is generated at 1/4λ from open end of the feeding line, and thus the current on the radiator flows in the reverse direction compared with that on feeding line. Since the direction of the current on the ground becomes also opposite from that on the feeding line, it is the same direction of the current on the radiator. The strong electric fields are excited at vicinity of A and B points, with the minimum surface current. Therefore, the polarization of the antenna is linear polarized along x axis.

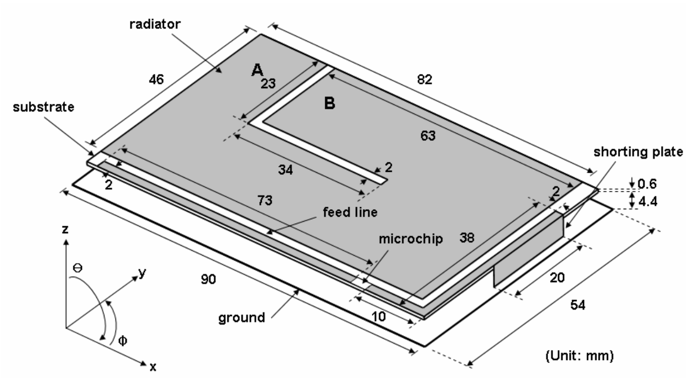


Fig. 1. Structure of the proposed antenna

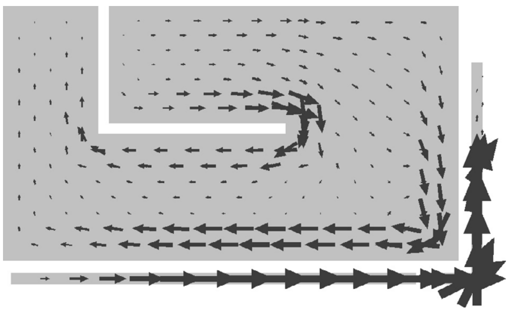


Fig. 2. Surface current on the patch and feeding line

III. MEASUREMENT AND RESULTS

Measurement of the proposed antenna is based on back-scattering data and was carried out in the anechoic chamber. The scattering methods, in general, give better measurement results than the transmission measurements in the case of small antennas, because the antenna radiation in the transmission measurements is disturbed by the feed line connected to the antenna [5]. Measurement system is separated into two parts: transmitting and receiving systems. The transmitting system consists of the RFID reader and antenna that transmit the communication signal to wake up the tag. The power of the reader is controlled by the variable attenuator. The receiving system includes a receiving antenna and spectrum analyzer in order to distinguish the back-scattering data. When the tag is waked up by reader's signal, it transmits the back-scattering data which can be detected by the spectrum analyzer. The minimum power (P_{tx}) of the RFID reader to wake up the tag is measured. The Fig. 3 shows the minimum power bandwidth of the antenna on metallic plate for different sizes (125×150mm^2, 250×300mm^2). All the peaks have been normalized to 0dB. It is noticed that the bandwidth with the variation of the measured power within 3dB is indicating very good tolerance to different platforms. The reading distances of the antenna for different sizes of metallic plate are shown in Table 2. The radiation patterns of the antenna placed in free space and mounted on metallic plate with varying the size are shown in Fig. 4. The radiation patterns are measured by the minimum transmitted power from the RFID reader. Those were normalized to the maximum value of them. In general, the back-radiation of the antenna decreases as the size of the metallic plate (ground plate) becomes larger. However, the proposed antenna has an advantage that the degradation of the efficiency is reduced against the metallic objects.

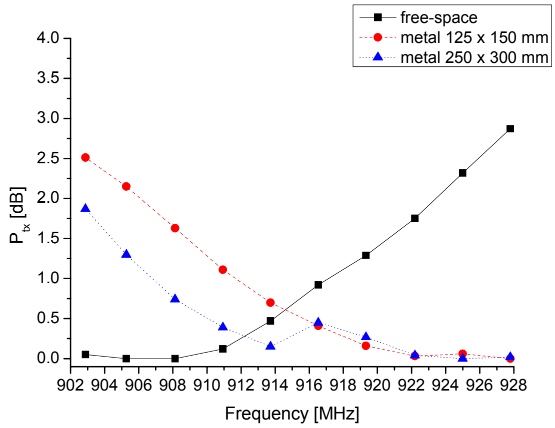
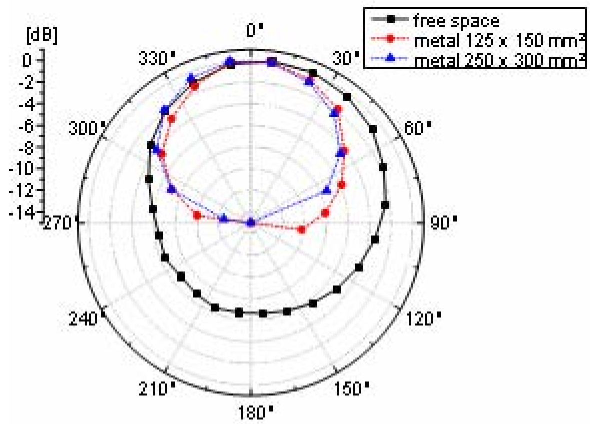
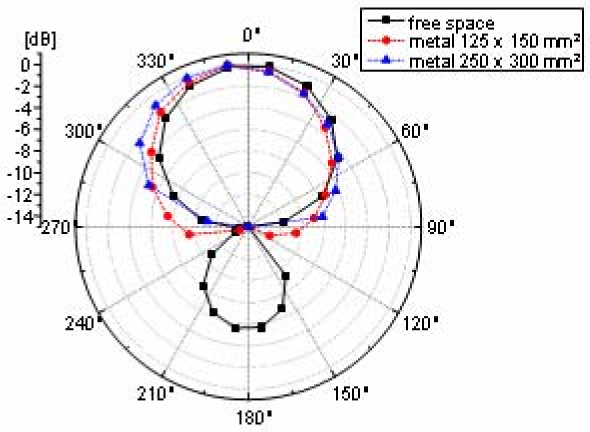


Fig. 3. Measured power bandwidth



(a) E_θ on y-z plane



(b) E_φ on x-z plane

Fig.4. Measured radiation patterns

TABLE I
MAXIMUM READING DISTANCE FOR METAL SIZES

	Maximum reading distance
Free-space	6m
Metal 125×150mm^2	4.8m
Metal 250×300mm^2	5.2m

IV. CONCLUSIONS

The microstrip antenna mountable on metal surface is proposed for the RFID tag. Feeding is by the proximity inductive coupling between feeding line and radiator on the ground. The real and imaginary parts of the impedance of the proposed antenna can be easily adjusted by using the proximity feeding, for the conjugation matching. Therefore, the degradation of antenna performance on the metal surface is reduced comparing with conventional antennas. The method about reduction of the antenna size and the improvement of the reading distance will be studied in future.

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